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SPEECH GIVEN BY LT. CDR. J. H. NICHOLSON, USN, TO THE ARCTIC INSTITUTE OF NORTH AMERICA AT MONTREAL, CANADA, ON OCTOBER 26, 1961.

THE NUCLEAR SUBMARINE AND THE ARCTIC

The transpolar voyage of the USS NAUTILUS in 1958 and surfacings of USS SKATE, USS SARGO, and USS SEADRAGON at the north pole have stolen most of the headlines as far as submarine arctic cruises are concerned. Other accomplishments of these ships, however, have more clearly demonstrated the potential value of the SSN as an arctic research vessel. In the summer of 1958, after surfacing in a small polynya (or lake) 40 miles from the pole, SKATE submerged and headed toward the last known position of ice station Alpha, an ice floe manned by 29 Air Force and scientific personnel. Despite the fact that the exact position of the ice floe was not known (even to Alpha personnel themselves due to cloudy weather for several days), and the fact that the floe was about 300 miles away in the center of the zone of inaccessibility, SKATE located the station and surfaced in a small lake immediately adjacent to the station. (Major Bilotta, the Commanding Officer of the station, stated that the sight of that submarine surfacing alongside him was the most errie experience he had ever had.) Enroute to the station, SKATE made 16 knots at a depth of several hundred feet beneath the ice and continuously gathered oceanographic data -- precise soundings, salinity and temperature of the water, measurements of ice thickness by electronic means, marine samples, ambient light readings, etc. Never before had it been possible to collect so much information in the arctic so accurately and so quickly. At ice station Alpha, SKATE crewmen and scientists visited the ice station scientists' Quonset huts and witnessed the experiments in progress. Alpha, scientists toured the SKATE. Our mutual exchange was rudely interrupted when a sudden ice movement started closing our lake and made it desirable for us to submerge. There were no Navy volunteers to remain on the ice floe -- and no Air Force or scientist volunteers to leave via the submarine. SKATE continued her exploration for a total of 10 days in or under the ice. As a matter of interest, ice station Alpha had to be abandoned shortly after we left as she was broken into pieces by the tremendous pressure of the ice.

The above single incident during SKATE'S cruise illustrates the ability of submarines to take continuous scientific data, at different depths in different locations quickly, unobserved, in relative comfort and safety. It further demonstrates the precise navigational ability of the submarine -- an unusual ability in this area.

Another example of the unusual capability of the submarine occurred during the SARGO cruise in the winter of 1960. After having transited 1200 miles of shallow, ice-covered water in the Bering and Chukchi Seas, and having surfaced through three feet of ice at the north pole, SARGO effected a rendezvous with another floating ice station north of Alaska. This time it was T-3, a floating ice island, which had broken off the ice shelf of Ellesmere Island. In a few hours,

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SARGO was able to make several passes under the island and determine the precise depth of the island below the surface, using the upward beamed fathometers. Previous measurement from above had been slow and expensive seismic soundings. Incidentally, one of our nuclear trained electricians was particularly impressed with the size of the ice island. He computed if he cut the island into ice cubes and put two in a highball glass every half hour, it would take 10^{18} years to get rid of the island (and he was ready to give it a try).

Another unique capability demonstrated by SARGO was the ability to break up through thick ice to surface for navigational, scientific, or emergency reasons. On arctic submarines, the top of the sail (or conning tower, as you may think of it) has been strengthened and the masts are designed to be retracted down into the sail. Thus, the top of the sail can be used as a "battering ram" to force the submarine to the surface in the winter when few openings are present. First, it is necessary to find a stretch of thin ice using the upward beamed fathometers. In the winter, such thin ice is usually a lead or polynya which has refrozen at the rate of three or four inches a day. It is then necessary to position the submarine in the middle of the opening with absolutely no way on the ship. If the ice is moving relative to the submarine, it is sometimes necessary to position the submarine on the Leeward edge of the opening to allow for drift. The tanks are then pumped to give positive buoyancy and the submarine heads up toward the ice. Frequent pumping or flooding is necessary to achieve the correct rate of ascent -- if it's too slow, the sail won't crack the ice; if it's too fast, the sail and masts may be damaged. Once the sail cracks the ice, the ballast tanks are blown to give additional positive buoyancy and eventually if the ice is three feet thick or less, the sail breaks through. Personnel can then go to the top of the sail through the bridge hatch and can go out on the ice via a Jacob's ladder. In all such surfacings, additional meteorological and oceanographic data is obtained. With the ability to surface through three feet of ice, the submarine has frequent opportunity for access to the surface. SARGO made 20 such surfacings during her cruise.

To give you an idea of the volume of scientific data a submarine can obtain during an arctic cruise, SARGO steamed over 6,000 miles in or under ice in a period of 31 days and 4 hours. Oceanographic, bathymetric and ice cover profile were continuously recorded. (For example, over 2 million precise soundings were recorded.) Compare this with drifting around on an ice floe for the years it would take to obtain comparable data (and being forced to obtain the data where the ice floe drifts, rather than where YOU want to go). Or compare the scientist on a submarine platform with one on an aircraft which has to locate a floe upon which it can land, break out the necessary equipment, take the readings, reload the equipment, then take off and look for another large floe.

A field in which the submariners are vitally interested and in which the submarine has provided hitherto relatively unknown data is the depth of pressure ridges. As you know, the arctic ice pack is laced with pressure ridges which extend up to about 30 feet above the surface of the floes. We are interested in how far these ridges extend below the floe, not only to permit us to travel at a safe depth when transiting, but to be able to avoid ridges when surfacing. Almost every opening is surrounded by deep ridges which can offer a threat to the submarine. We have found several interesting things about these ridges. First, there is a definite relationship between the depth below the ice and the height above the ice. The depth is 3 to 5 times the height. Thus, many ridges are over 100 feet deep. (As a matter of interest, the deepest ridges in the entire arctic are to be found close to the Canadian Archipelago where the prevailing current and winds have exerted tremendous force against the land.) Using the data obtained on submarine cruises and air reconnaissance flights,the U.S. Hydrographic Office has developed empirical concepts to forecast the number and depth of ridges to be encountered. This is particularly significant in shallow water transits such as the SARGO winter transit through the Bering and Chukchi Seas. The average depth of the water for over 1,000 miles was less than 180 feet with some water as shallow as 105 feet. With ice ridges occurring as often as fifty per mile and with some projecting down over 100 feet, there was not room for the submarine to go under the ridges -- it was necessary to weave between the ridges using sonar information in much the same manner as penetrating a minefield. The ice forecast was utilized to plan the track to avoid as many of the ice ridges as possible. The ice forecast also assisted in selecting areas where surfacing opportunities would be maximized.

Although there are no icebergs in the Arctic Ocean, there are many in Davis Straits and the North Atlantic. In 1960, USS SEADRAGON demonstrated the capability of the nuclear submarine to detect and avoid icebergs during her historic transit of the Northwest Passage. This cruise was also a fine example of cooperation between our two wonderful countries in arctic research.

It would be impossible for me to discuss the submarine in the Arctic without mentioning the contribution of the scientists. No more competent, dedicated men ever lived than such men as Dr. Waldo Lyon and Mr. Art Roshom of Naval Electronics Laboratory; Mr. Walt Wittman and Mr. Art Malloy of the Hydrographic Office, to mention only a few who made the cruises. A small group of scientists has accompanied each submarine on the arctic cruises. Their assistance and advice has been a vital factor in the development of equipment, techniques and experience necessary to operate safely and effectively in that unique ocean. Concurrently, it has been possible to obtain voluminous scientific data. A brief description of how such a scientific program is organized might be of interest.

A scientific director and coordinator has been designated by the Chief of Naval Operations well in advance of each cruise. Each of the interested activities, commands and laboratories is then invited to submit recommendations for a scientific program for the cruise. Using these recommendations, the Scientific Director prepares a scientific program for approval by the Operational Commander and the Chief of Naval Operations. Once the program is approved, the Director coordinates the acquisition and installation of the necessary instrumentation with the ship. In cooperation with the ship, a watch bill is then prepared to ensure that all desired data is properly obtained and logged. The data is then forwarded to the appropriate activity for analysis and promulgation.

Already our nuclear submarines have gathered more data in certain oceanographic fields in the Arctic than was collected in the previous 75 years. A recent development will increase the amount of data which can be gathered on future cruises and will greatly accelerate the analysis of the data. A submarine oceanographic digital data system has been built. This system will automatically collect data such as depth, sound velocity, sea temperature, ambient light and conductivity. Time, date and submarine position are recorded simultaneously with the above readings. Even more significant, the data is put on digital punched paper tape which can be fed into the Hydrographic Office computer for further analysis.

Tonight I have discussed some of the scientific aspects of the submarine in the Arctic. No one realizes better than I that this is only a small part of the Arctic research field. Some fields, such as meteorology, bottom sampling, glaciology, etc. can best be done from ice floes. Other work must be done in the laboratory. The important point is that we have not yet begun to scratch the surface in the collection and analysis of all the data acquired. Despite thousands of years of experience in the other oceans of the world, we are just beginning to realize how little we really know about oceanography and sound propagation. In the Arctic, with only a few years' of experience, even less is known. I can think of no area on earth which offers more scientific challenge. I am sure that everyone here tonight is fully aware of the military importance of the Arctic Ocean. Control of the seas is mandatory if we are to survive. Other oceans can be controlled by combinations of ships, submarines and aircraft, but the Arctic can only be controlled by nuclear submarines. The Soviet Government has claimed that Russia possesses a fleet of missile-carrying nuclear submarines. In the event of war, we must be capable of detecting and destroying enemy submarines wherever they may be found -- even under the Arctic ice pack. This will require new techniques and may require entire new concepts. We must continue to improve our capability to fight in this environment, if necessary. To do this effectively will require the skills and cooperation of all our military services, our industries, our scientific organizations and our countries. Past performance as exemplified by Commodore Robertson, makes me certain that we can solve our military requirements and at the same time make significant contributions to the scientific knowledge of inner space.